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ABSTRACT

A 440C shaft, delivered to the Materials and Processes Group for failure analysis, was part of the LOX interconnect valve. The valve had been operated approximately 100 times before it became inoperative and was the second failure of this type. Failure was attributed to fatigue of surface structure embrittled by grinding practice.

KEY WORDS

Fatigue

Grinding

Magnetic inspection

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APPENDIX

TITLE

PAGE

A

Analysis of Failure of Cam
Shaft S/N 19

A-1

1.0 OBJECT

To determine cause of failure

2.0 BACKGROUND

It is estimated that the failed shaft operated the LOX interconnect valve approximately 100 times before failure. This is the second occurrence of a reported failure of this type of part.

3.0 CONCLUSIONS

- 1) Failure occurred in a fatigue manner emanating from a shallow ~~circ~~ circumferential crack. This crack could have been initiated during the operation of the shaft or have been present at time of installation.
- 2) Hardness and analysis were proper for AlSi 440C.

4.0 RECOMMENDATIONS

- 1) All shafts should be given a magnetic inspection prior to installation and rejected if defects are seen.
- 2) The condition of all installed shafts should be determined if possible.
- 3) Grinding practice should be controlled to preclude overheating and development of untempered martensite and resultant cracks or crack sensitive structure.
- 4) An Austenitic type material would be more compatible to a cryogenic atmosphere.

5.0 PROCEDURES AND RESULTS

- 1) The broken shaft was given a magnetic inspection and photographed. In addition to the failed area 5 cracks were observed. (Figure #1).
- 2) The fractographic study indicates a failure in a bending manner. (not torsional) Six distinct areas of failure can be observed on the fracture face. (Figure #2).
- 3) The shaft was cross sectioned and the cross section photographed (Photo # 1). Note: the depth of the cracks revealed in magnetic inspection. Photos # 2 and 3 show one of these cracks at greater magnification. Note the intergranular nature. Overload failure would show transgranular failure.

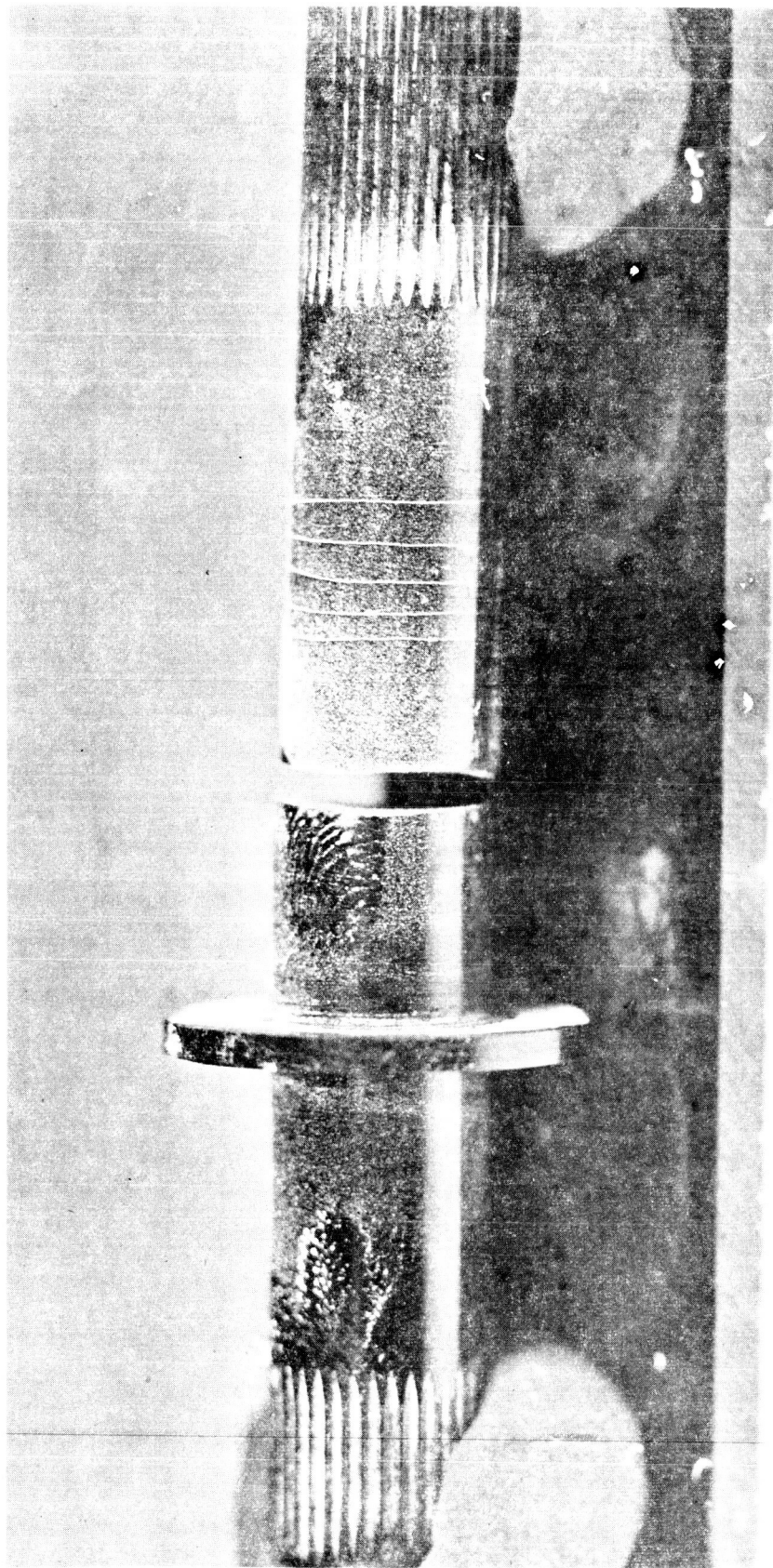
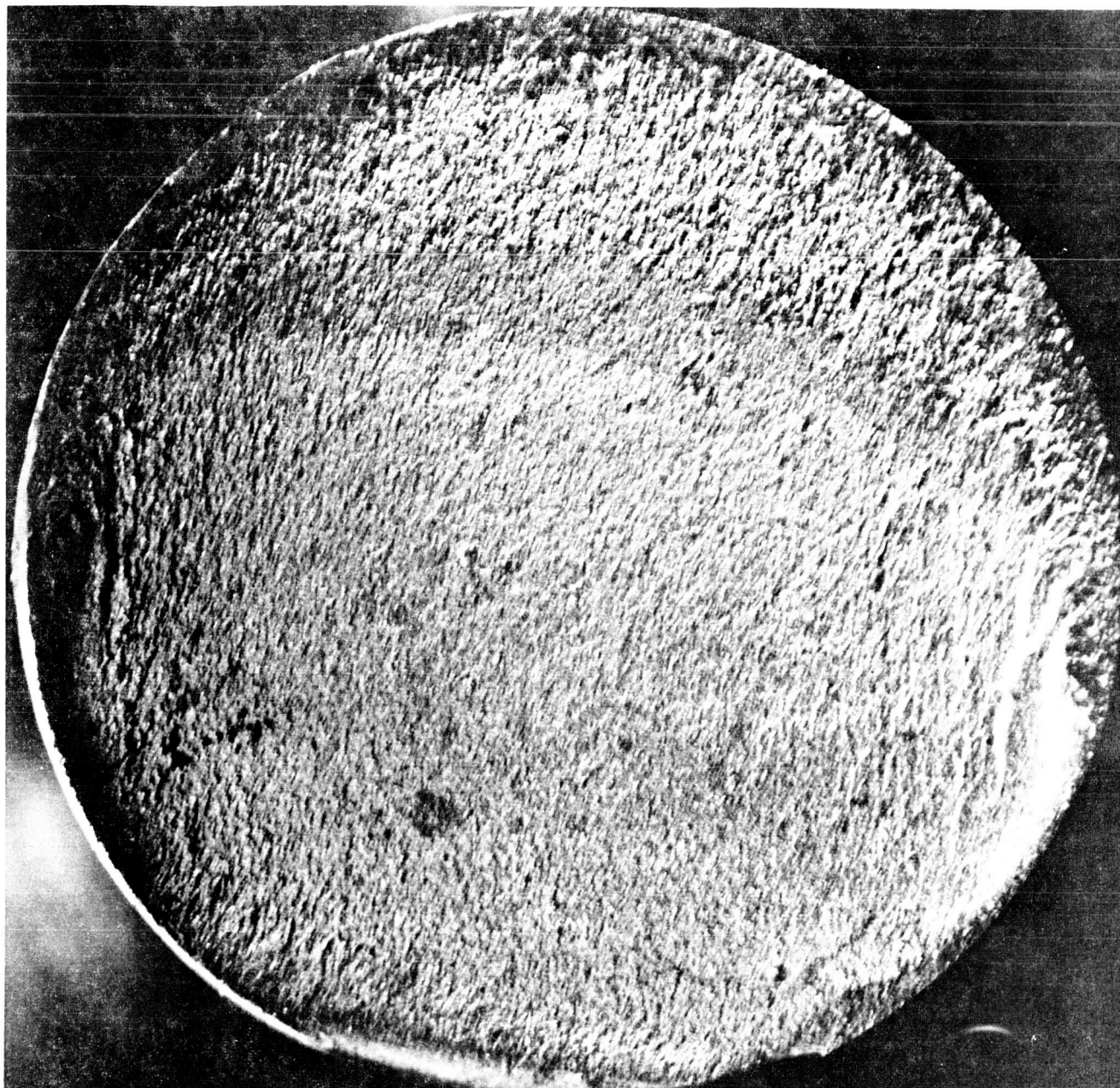


Photo of Magnetic Indications on Shaft

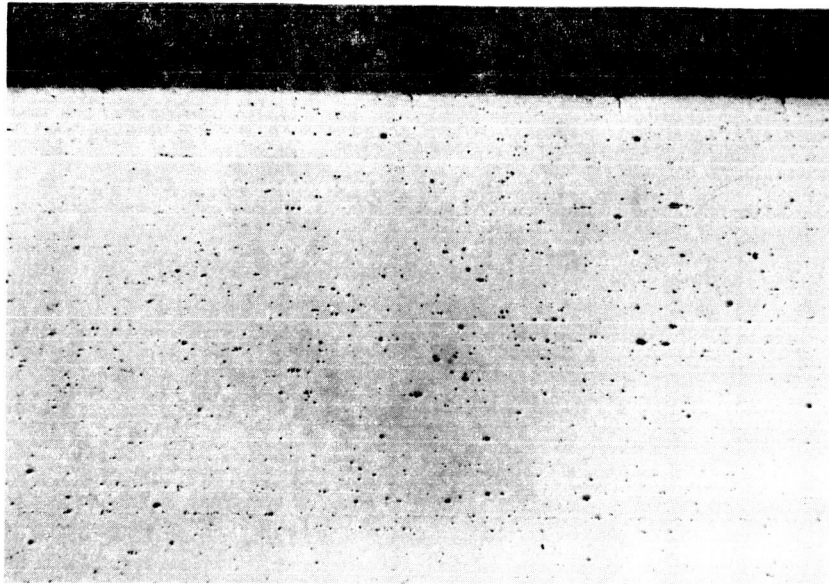
Figure #1



Fracture Face of Shaft

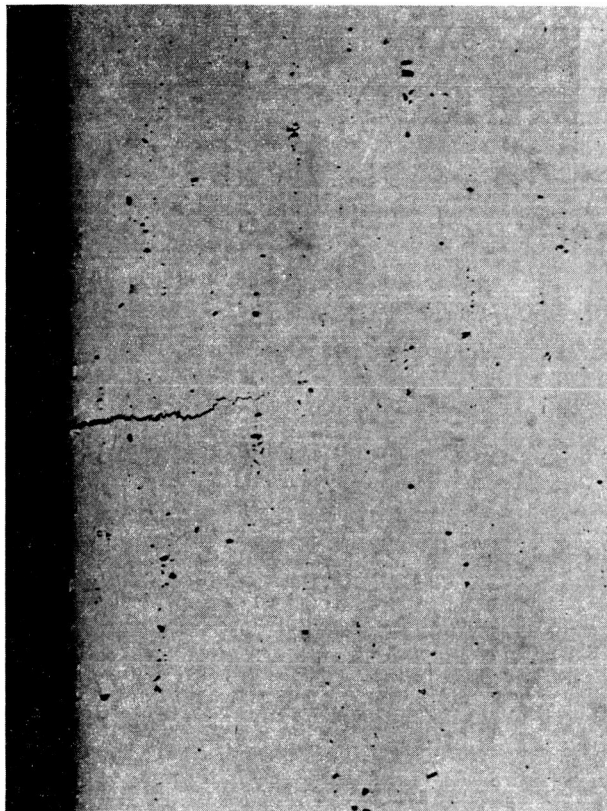
Note Stages of Progressive Failure

Figure #2



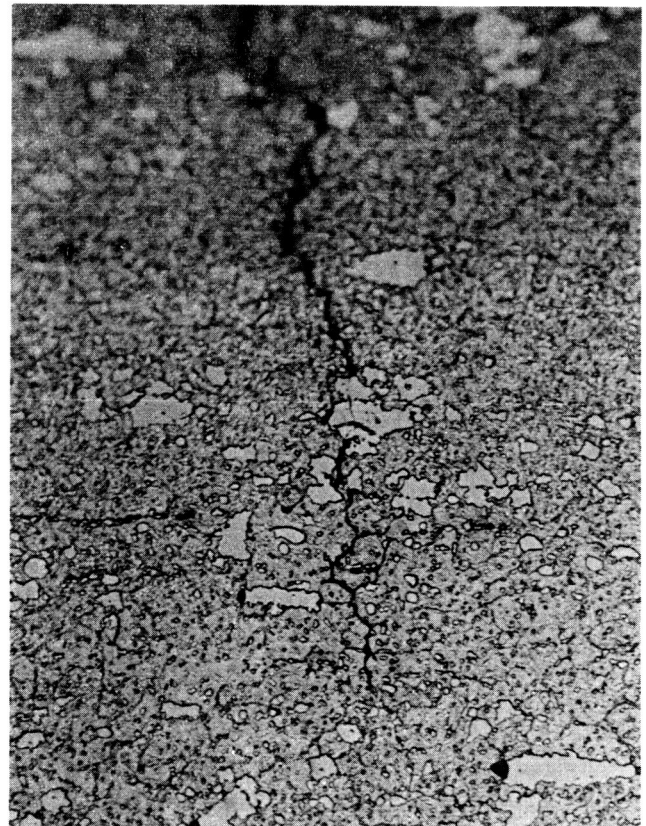
Cross Section of Magnetic Indications (8X)

Photo #1



Cross Section (100X)

Photo #2



Cross Section (500X)

Photo #3

Figure #3

APPENDIX A
ANALYSIS OF FAILURE OF
CAM SHAFT S/N 19

1.0 OBJECT

To report failure of cam shaft P/N 135062 S/N 19.

2.0 BACKGROUND

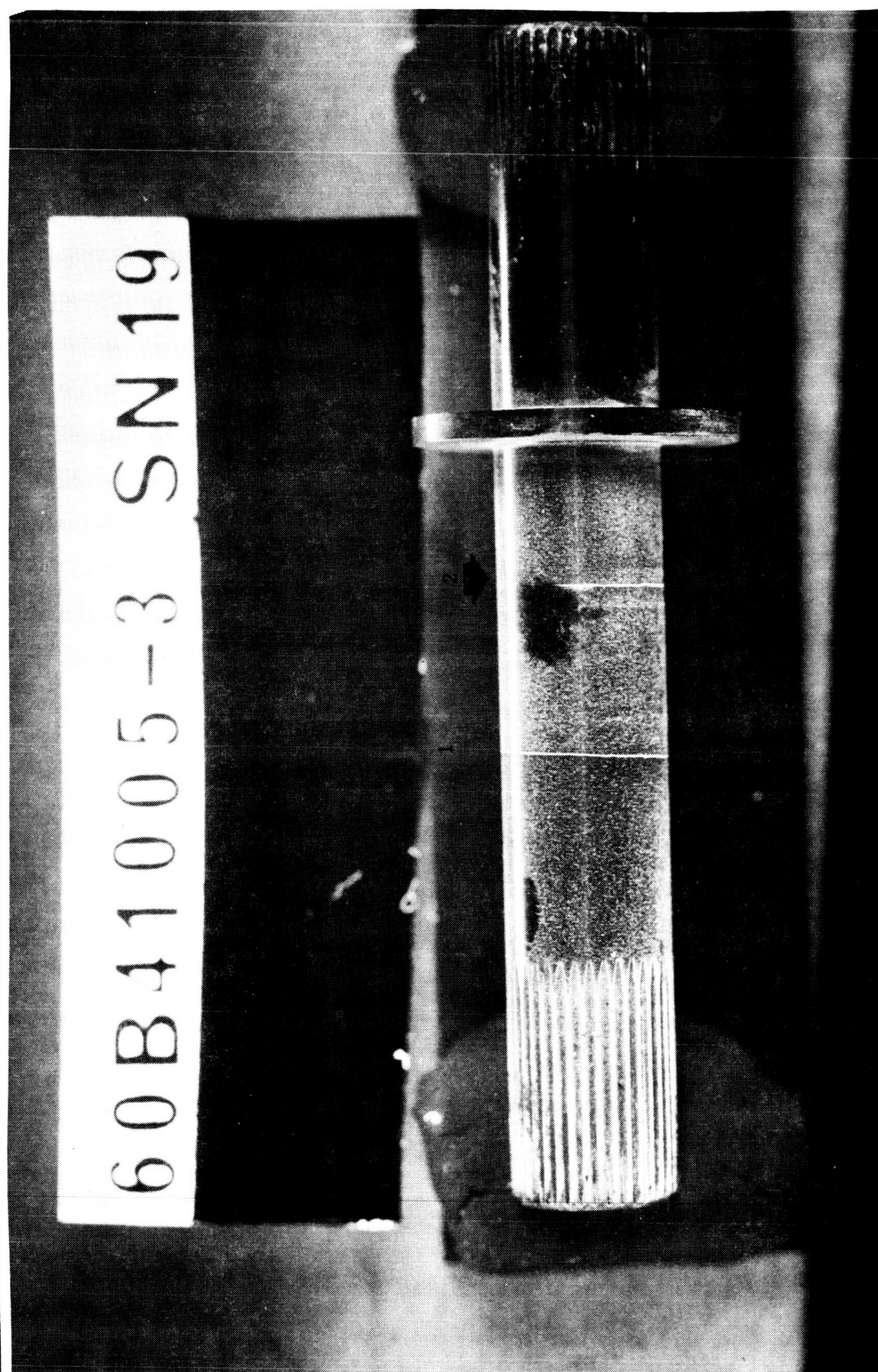
Due to the failures incurred in previous valves it was decided to disassemble seven additional valves which were used on test R444 or for PFCT and magnetically inspect the cam shaft (P/N 135062).

3.0 PROCEDURES AND RESULTS

Magnetic inspection of the shafts revealed cracks in S/N 19, identical to those reported on previous failed shafts. (Figure #1). This shaft was sectioned and microscopically inspected. Photo A and B of Figure #2 show the extent of failure of this shaft. Crack #1 was much longer than those previously observed. No cracks were seen on any of the other shafts inspected. Photo C of Figure #2 shows the intergranular mode of propagation of the #1 crack.

4.0 CONCLUSIONS

The cracked shaft (S/N 19) was close to catastrophic failure.



Magnetic Particle Indications on Failed Shaft.

NOTE: Crack #2 indicated by arrow does not extend completely around shaft.

FIGURE # 1

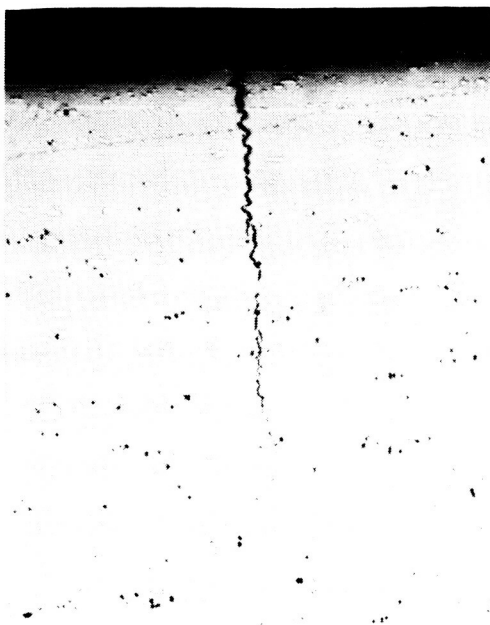


PHOTO A 100X
 Cross Section of Crack # 1.
 Note that this crack is much
 more extensive than those
 previously observed.



PHOTO B 100X
 Cross Section of Crack # 2.

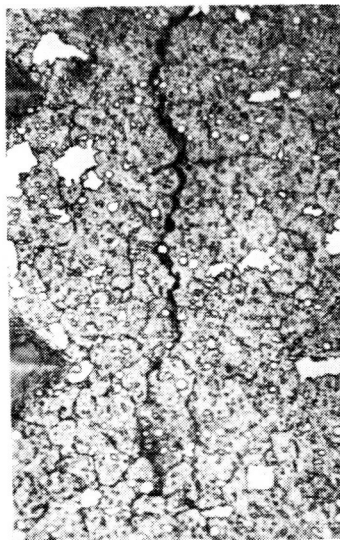


PHOTO C 500X
 Etched Section of Crack # 1.
 Note intergranular mode of
 propagation.

FIGURE # 2